Space Weather Technical Forecast

Issued on Friday 13 December 2024 at 01:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Moderate Solar Activity likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate activity, with two M-class flares observed. Peak flare was an M2.2 at 12/1743 from AR3922 in the southeast, with a further M1.6 at 12/2107 from the same region. There are five sunspot regions on the disc, with this region among the smaller of the groups on the disc. This is hard to analyse due to its location and small size, but perhaps has a very weak delta spot on its trailer. The most notable region is AR3917, in the southwest, which has seen notable growth in penumbra extent, to become a moderately sized region with a weak delta spot, however any activity from this region has been limited to C-class flaring. AR3920, in the north-centre, is also moderately sized, but has shown signs of simplification and maturation, with a separation of its two main spots.

There are no Earth-directed CMEs, with the recent filament eruptions either passing to the south or far off from the Earth-Sun line. However SOHO manoeuvres have limited available imagery, lowering confidence. There are currently no coronagraph images available to assess any CME from either of the M-class flares.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1 showed an ongoing slow wind regime. Solar wind speed were at Background 330-370 km/s, with density below average. Interplanetary Magnetic Field (IMF), Bt, was Weak, peaking at 6nT, with the north-south component, Bt, varying between -5nT and +5 nT. Phi angle was positive (away from the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at Background. High energy electron flux (greater than 2MeV) observed by GOES16 showed a diurnal variation from Moderate to High, peaking at 1180pfu at 12/1450UTC. The associated 24-hour fluence was below Active, initially rising slightly, but now steady. The 13/0000 UTC observation was 3.8e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely, with isolated M-class flares. There is a slight chance of X-class flares.

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Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Slow wind conditions are expected until CH99's onset, most likely on Day 2 into Day 3 (14-15 Dec). Geomagnetic activity is expected to start mostly Quiet as a result, then rising to give a spell of Unsettled to Active with a Slight Chance of G1 Minor Storm intervals. Activity easing later Day 3 and Day 4 (15-16 Dec), to be Quiet with isolated Unsettled intervals.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at Background, but with a slight chance of rising in response to any notable flares High energy electron flux is expected to be at mainly Moderate levels, but perhaps peaking at High, before falling Days 2-3 (14-15 Dec) due to any inbound fast wind. Some recovery is then likely Day 4 (16 Dec) as solar winds ease. The 24-hour fluence is expected to remain below the Active threshold.

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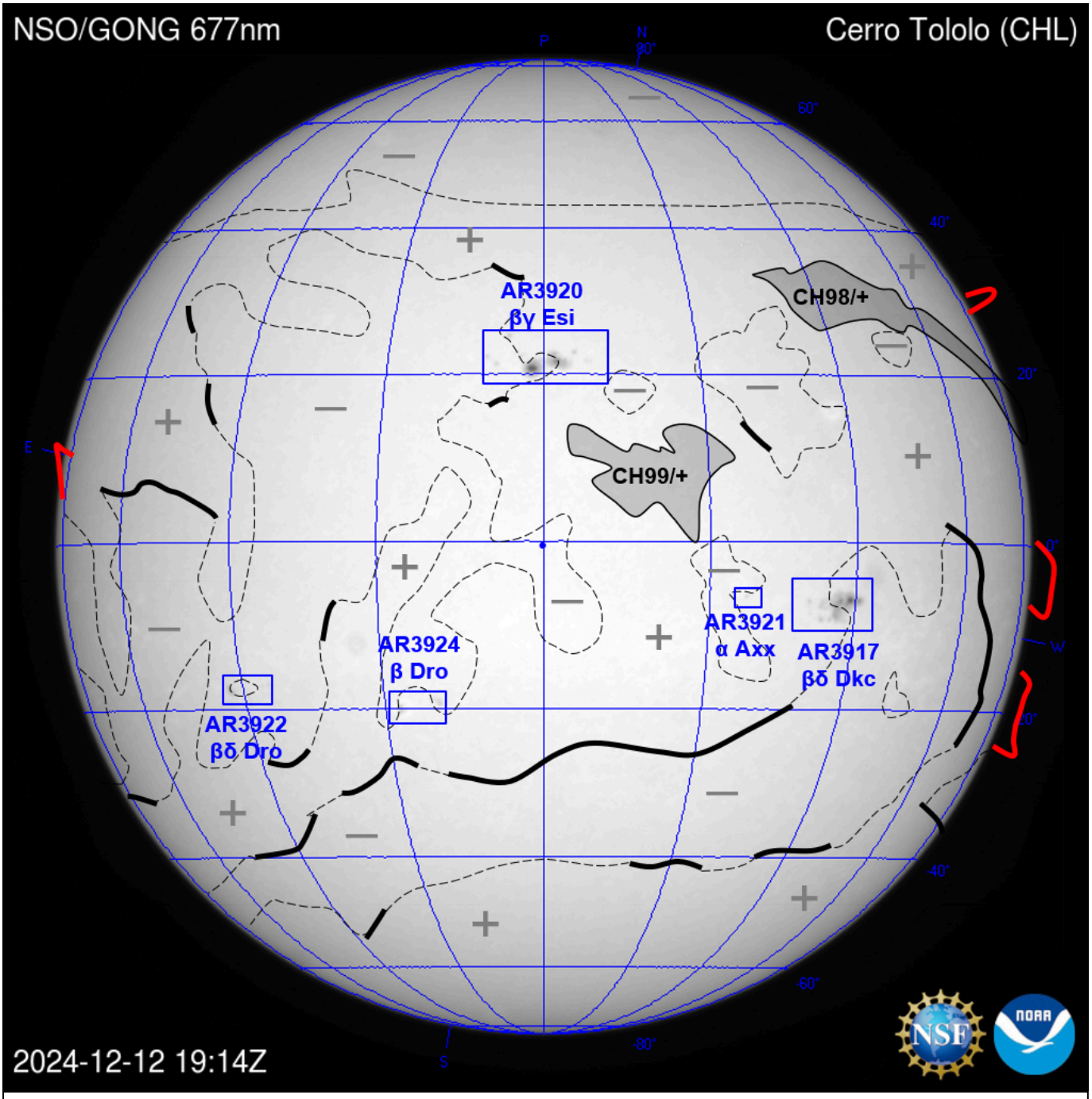
Figure 1: MOSWOC Solar Synoptic Map 12/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There are no Earth-directed CMEs, with recent eruptions either far-sided or directed mainly to the south or north. However the Earth-facing disc has a number of filaments that could become CME sources, and two of these are notable due to their length. The first is mainly north-south aligned across the southern disc and perhaps the most mobile, but now approaching 75W, with a decreasing potential for an Earth-directed eruption. The second is an east-west filament spanning roughly 50 degrees of the central-disc between 20 and 30S, but currently appears relatively stable.

Current background slow wind conditions, and mainly Quiet geomagnetic activity are expected until the onset of the next enhancement, from the fast winds of CH99+. This is a persistent feature, and was likely the cause of a weak enhancement that occurred on the previous rotation on 18 Nov. This resulted in winds speeds of around 450km/s, and would map to this rotation to give an arrival on Day 3 (15 Dec) and perhaps earlier if a stronger fast wind is observed. Despite the slightly elevated winds from CH99's previous rotation, there was little impact on the geomagnetic activity, although the persistence of the feature increases the potential for the development of a more notable CIR region, and consequently the chance of reaching G1 Minor Storm. However, activity is most likely to be in the Unsettled to Active range, before easing back to Quiet to Unsettled later Day 3 and Day 4 (15-16 Dec).

MOSWOC Enlil is currently showing a weak enhancement on Day 2 (14 Dec), which is currently believed to be too quick in connecting to the HSS from CH99, but does increase confidence for a connection to be observed. This is then followed by a more notable enhancement in the model occurring on 16 Dec, which is too late to be from CH99 and has no observable source region currently on this disc. This is subsequently considered anomalous and should be disregarded.

Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	10	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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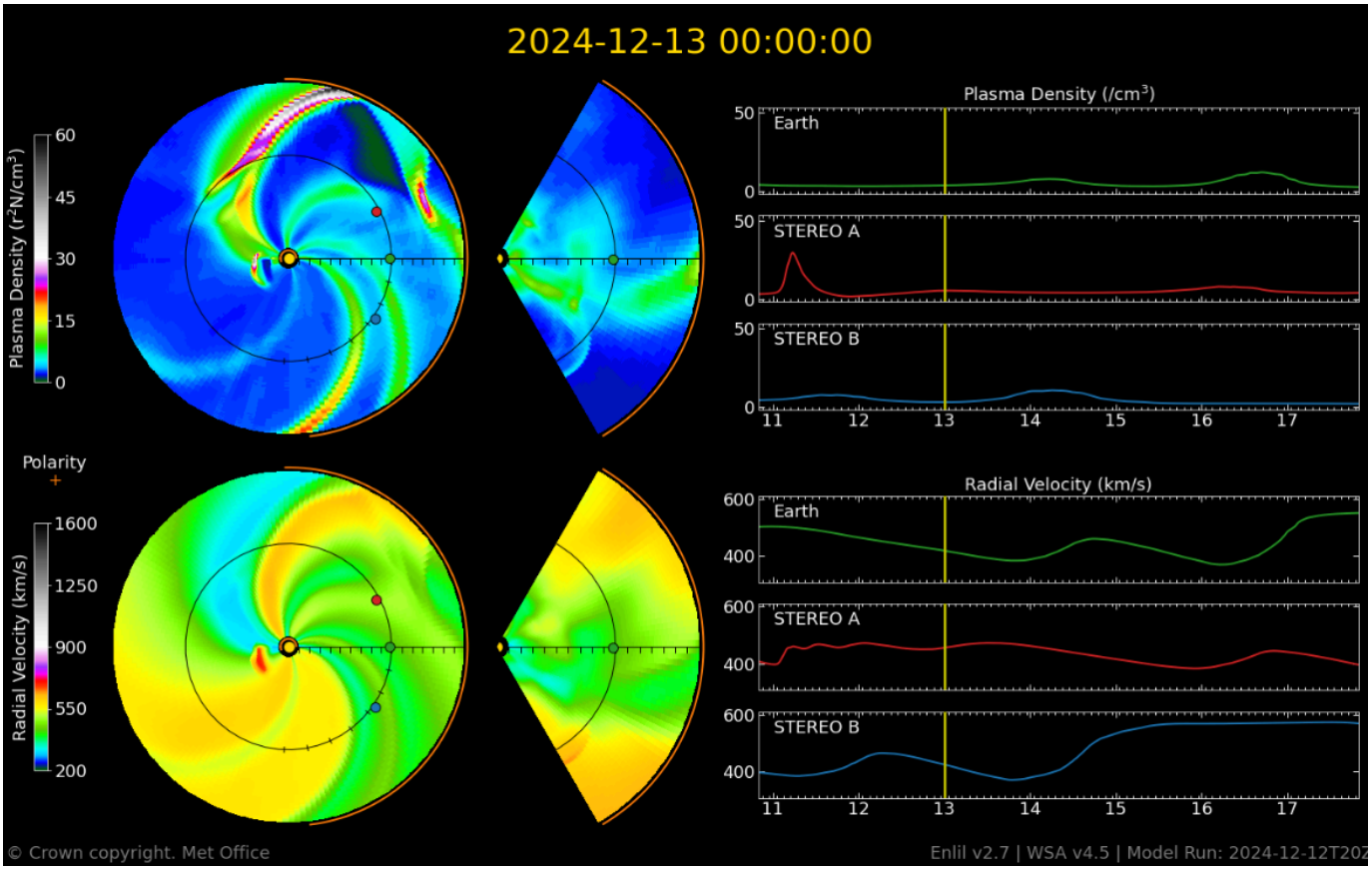
Figure 2: MOSWOC Enlil, showing weak enhancement on 14 Dec, and anomalous enhancement from 16 Dec onward.



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Radio Blackouts - X-Ray Flares

There are five sunspot regions currently on the Earth-facing disc, however this includes two moderately sized regions, and a further small region that has been more active than it's initial appearance would indicate, and then two further smaller and simpler regions. The most notable is now AR3917. This is has seen a gradual increase in penumbral area over the recent 24 hours, resulting in the formation of a weak delta spot, and the development of an east-west aligned polarity separation line. This would typically be accompanied with the potential for increased activity, however this region has so far been limited to low C-class flares. The other moderately sized region is AR3920, however this continues to very gradually simplify and mature into a more open group, after its growth on 10-11 Dec .

The most active region remains AR3922 in the southeast disc, which at first glance appears to be a very small and simple bipolar group, but has been a source a number of M-class flares over the previous days, accompanied with some jet-type CMEs. The cause of this regions activity appears to be a very small delta spot within its trailer, although foreshortening and the limitations of resolution with the H-alpha imagery makes this identification only a tentative one for the time being. The other two regions are smaller and simple, with AR3924 recently numbered, as a recent emergence in the south-west disc and AR3921 a very small unipolar group to the east of AR3917.

Despite the limited number of sunspots on the disc, the current forecast activity is increased over what would typically be expected, due to the mixture of increased complexity of AR3917 and the history of AR3922. There also continues to be the potential for further regions to rotate onto the disc from over the southeast limb, with some clear magnetic structure evident on e.g. GEOS SUVI aia-171, which may have its source in a notable active region.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	65	60	60
Very Active	R3-R5 (X Class)	No	10	10	10	10

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Figure 3: GOES 16-18 X-ray Flux

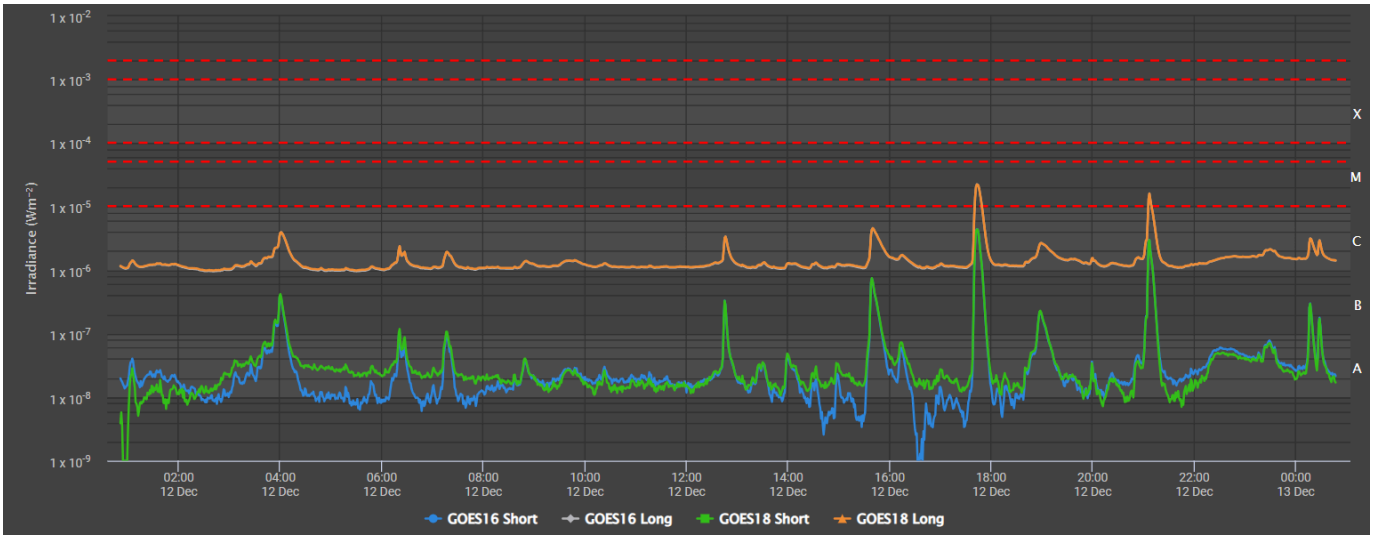
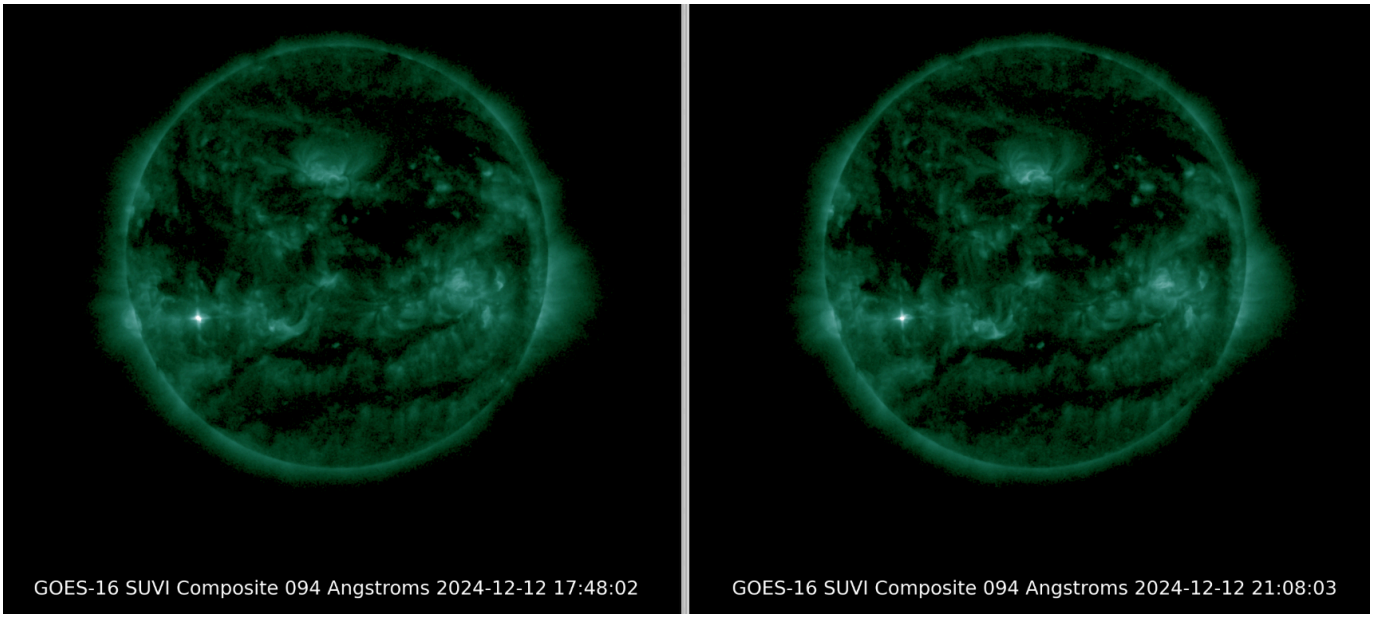


Figure 4: Two recent M-flares from small region AR3922 in the southeast on GOES SUVI 094



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Solar Radiation Storms (High Energy Protons)

GOES-18 proton flux is expected to persist at background levels with only a slight chance of a response from any of the regions on the disc, most likely AR3917, which despite being a relatively inactive region, has exhibited some ongoing development. The potential for an observable proton enhancement from ex-AR3912, while not impossible early in the period, is now becoming increasingly less likely as it moves further onto the far-side.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been mainly Moderate, but reached High at diurnal maximum on 12 Dec, due to the fast wind enhancement that occurred on 9-10 Dec. This is expected to maintain this Moderate to High level day 1-2 (13-14 Dec), until the onset of any fast wind of CH99/+. This is most likely to occur late on Day 2-3 (14-15 Dec), with a likely dropout in observed flux as a consequence of the increased solar wind pressure. The flux is then expected to recover back to Moderate, perhaps High values as the Van Allen belts ease back to GEO later day 3 and through day 4 (15-16 Dec).

The associated 24 hour fluence has been rising, but appears to have peaked at around 4e7 integrated flux, still well below the Active threshold (1e8 integrated flux). This is expected to persist at around this level at first, but then easing through day 2 and day 3 (14-15 Dec). This trend is supported by REFM, although this is underestimating current fluence values. Any recovery of flux day 3-4 is currently not expected to have sufficient time to reach the Active fluence level during this period, but may have a slight chance of reaching this level day 5 onward (17 Dec).

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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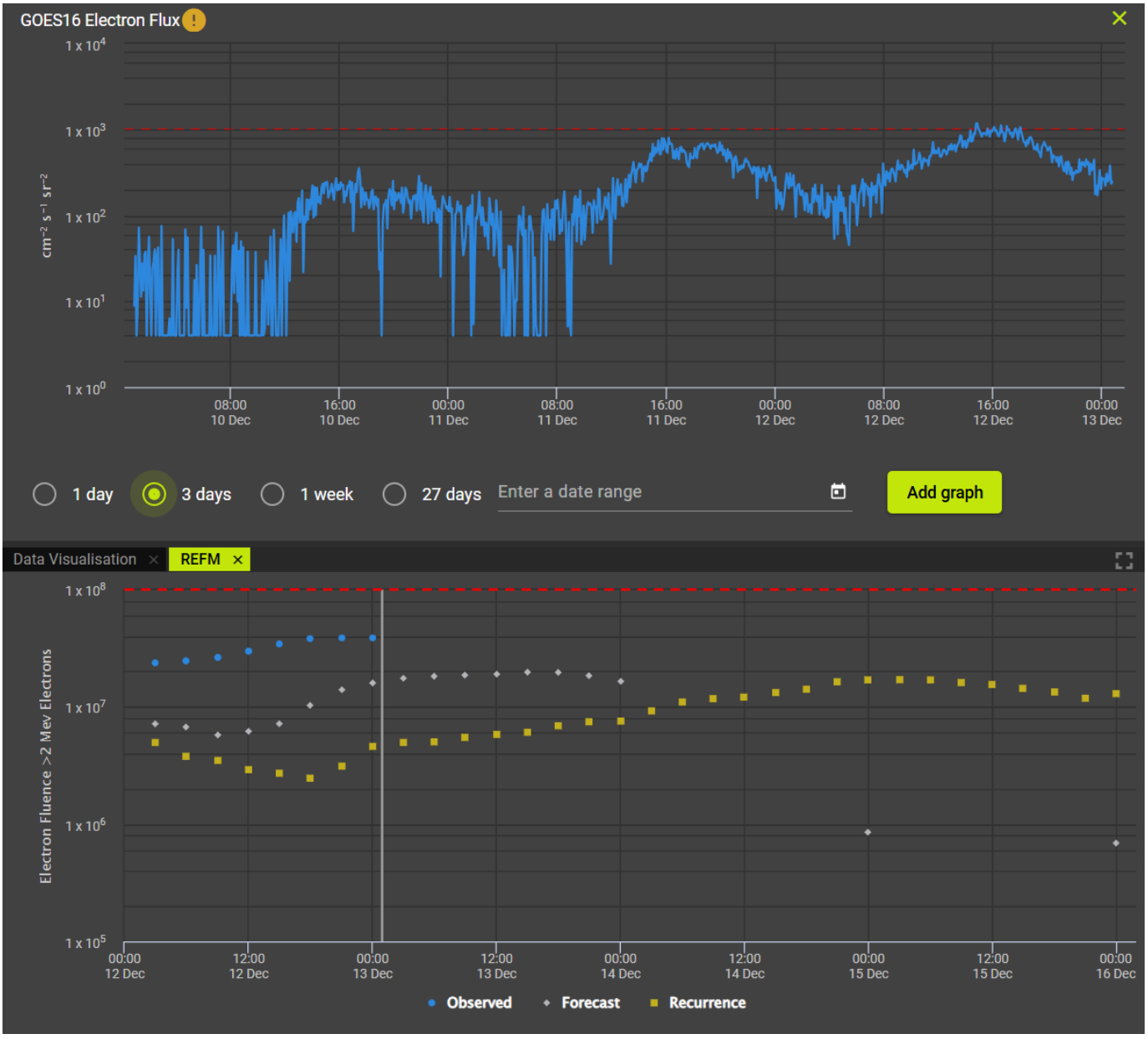
Figure 5: GOES-16 >2 MeV Electron Flux (top, last 3 days) and associated 24hr Fluence with REFM and Recurrence (bottom)



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